

## Research Report

# Specific language impairment in language-minority children from low-income families

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### Abstract

**Background:** Recent evidence suggests that specific language impairment (SLI) might be secondary to general cognitive processing limitations in the domain of executive functioning. Previous research has focused almost exclusively on monolingual children with SLI and offers little evidence-based guidance on executive functioning in bilingual children with SLI. Studying bilinguals with SLI is important, especially in the light of increasing evidence that bilingualism can bring advantages in certain domains of executive functioning.

**Aims:** To determine whether executive functioning represents an area of difficulty for bilingual language-minority children with SLI and, if so, which specific executive processes are affected.

**Methods & Procedures:** This cross-cultural research was conducted with bilingual children from Luxembourg and monolingual children from Portugal who all had Portuguese as their first language. The data from 81 eight-year-olds from the following three groups were analysed: (1) 15 Portuguese–Luxembourgish bilinguals from Luxembourg with an SLI diagnosis; (2) 33 typically developing Portuguese–Luxembourgish bilinguals from Luxembourg; and (3) 33 typically developing Portuguese-speaking monolinguals from Portugal. Groups were matched on first language, ethnicity, chronological age and socioeconomic status, and they did not differ in nonverbal intelligence. Children completed a battery of tests tapping: expressive and receptive vocabulary, syntactic comprehension, verbal and visuospatial working memory, selective attention and interference suppression.

**Outcomes & Results:** The bilingual SLI group performed equally well compared with their typically developing peers on measures of visuospatial working memory, but had lower scores than both control groups on tasks of verbal working memory. On measures of selective attention and interference suppression, typically developing children who were bilingual outperformed their monolingual counterparts. For selective attention, performance of the bilingual SLI group did not differ significantly from the controls. For interference suppression the bilingual SLI group performed significantly less well than typically developing bilinguals but not monolinguals.

**Conclusions & Implications:** This research provides further support to the position that SLI is not a language-specific disorder. The study indicates that although bilingual children with SLI do not demonstrate the same advantages in selective attention and interference suppression as typically developing bilinguals, they do not lag behind typically developing monolinguals in these domains of executive functioning. This finding raises the possibility that bilingualism might represent a protective factor against some of the cognitive limitations that are associated with SLI in monolinguals.

**Keywords:** specific language impairment, bilingual, executive function, language-minority, poverty.

### What this paper adds?

*What is already known on this subject?*

Increasing evidence suggests that children with SLI can demonstrate executive function deficits and that bilingualism can enhance a variety of executive functions in typically developing children.

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*What this study adds?*

Previous research has focused almost exclusively on monolingual children with SLI. Also, the available research offers little evidence-based guidance on cognitive processing in bilingual children with SLI. This is the first study to explore a broader range of executive functions in a relatively homogeneous group of bilingual children with SLI from low-income families. They were compared with typically developing bilingual and monolingual children. Bilingual children with SLI demonstrated verbal working memory limitations and preserved visuospatial working memory functioning. Typically developing bilingual children outperformed typically developing monolinguals on measures of selective attention and interference suppression. Although bilingual children with SLI did not manifest the same advantages in selective attention and interference suppression as their typically developing bilingual peers, they did not lag behind typically developing monolinguals in these domains of executive functioning. This finding raises the possibility that bilingualism might play a role in the expression of a domain-general executive function deficit in SLI.

## Introduction

Specific language impairment (SLI) is a neurodevelopmental disorder that is diagnosed when a child has a primary deficit in acquiring language at the usual rate despite apparent typical development in other areas. Children with SLI generally struggle across a wide range of language abilities with marked difficulties in their use of grammatical morphology. The disorder is thought to have a genetic component and is not caused by hearing loss, emotional and behavioural problems, reduced intelligence, clear neurological impairments, social conditions or lack of linguistic stimulation (Bishop *et al.* 1995, Leonard 1998). In Anglo-Saxon countries, SLI has been shown to affect almost 7% of children (Tomblin *et al.* 1997). Clear prevalence estimates are, however, difficult to establish because of a lack of a commonly accepted clinical marker for SLI and controversies in the field about which linguistic and non-linguistics domains are affected (Bishop *et al.* 2000). Detecting SLI in language-minority children from low-income families is even more complex due to the additional challenge of determining whether low language scores are attributable to reduced linguistic exposure or the presence of a neurolinguistic impairment.

Bilingual children with immigrant origins can demonstrate linguistic profiles that superficially resemble those of children with SLI (Armon-Lotem 2012, Kohnert *et al.* 2009, Thordardottir *et al.* 2006, Paradis 2010). In two independent studies, typically developing language-minority children obtained first and second language scores more than 2 SD (standard deviations) below performance of monolingual speakers (Engel de Abreu *et al.* 2012, 2013). It has been suggested that these results could be due to children from socioeconomically disadvantaged language-minority groups experiencing a subtractive form of bilingualism if their first language is not valued outside of the home (Lambert *et al.* 1993).

Despite considerable efforts in the field, the aetiology of SLI is still unknown. According to one theoretical account, the language problems in SLI develop as

a consequence of a deficit or delayed maturation of an innately specialized language acquisition device (Clahsen 1991, Rice *et al.* 1995, van der Lely 1997). This position is challenged by increasing evidence showing that impairments in SLI are not specifically restricted to the linguistic domain, leading to the suggestion that the language difficulties might be secondary to cognitive/information processing limitations (see Bishop 1997, for a review). Some recent studies indicate that executive functioning might be deficient in individuals with SLI (Bishop and Norbury 2005, Bishop *et al.* 2006, Henry *et al.* 2012, Montgomery 2002).

'Executive functioning' is used as an umbrella term to refer to a series of cognitive processes that control thought, action and emotion and is commonly understood as a super-ordinate construct with multifactorial components including, among others, working memory, shifting and inhibition (Miyake *et al.* 2000). It remains unclear which specific executive functions are affected in SLI. The most consistent finding in the field points towards deficits in working memory (Archibald and Gathercole 2006b, 2007, Leonard *et al.* 2007, Marton and Schwartz 2003), a system for holding and manipulating information over brief periods of time in the course of ongoing cognitive activities. Working memory has been conceptualized to consist of specialized verbal and visuospatial short-term memory stores and a domain-general attentional control component (Baddeley 1986).

It has been argued that children with SLI have weaknesses in the domain-specific verbal short-term memory storage system (Archibald and Gathercole 2007, Bishop *et al.* 1996, Marton and Schwartz 2003) and some studies also report reduced performance on verbal complex span tasks which tap working memory storage and attention processes (Archibald and Gathercole 2006a, 2006b, Henry *et al.* 2012, Marton and Schwartz 2003). According to one theoretical account, domain-specific verbal working memory limitations in SLI constrain the processing and storage of speech material which negatively impacts language learning (Gathercole and

Baddeley 1990). Alternatively, poor performance on verbal working memory tasks might reflect a more general deficit in executive functioning (Henry *et al.* 2012). The few studies that have explored visuospatial working memory in SLI have yielded mixed results. Archibald and Gathercole (2006b) did not find differences between children with SLI and age-matched controls on visuospatial working memory tasks (see also Williams *et al.* 2000). Others report, however, weaker visuospatial working memory skills in children with SLI (Henry *et al.* 2012, Im-Bolter *et al.* 2006, Marton 2008). A similar degree of inconsistency in empirical findings exists for other executive functions. Some studies report inhibition, shifting and attention impairments associated with SLI (Henry *et al.* 2012), but others do not (Williams *et al.* 2000).

Whereas children with SLI can demonstrate executive functioning limitations, typically developing bilingual children have consistently been shown to manifest advantages over monolinguals on a range of executive function tasks, most notably in the domain of cognitive control (Adesope *et al.* 2010, Hilchey and Klein 2011). It has been argued that a bilingual experience may train certain executive functions that are needed to resolve conflict between competing language systems (Bialystok 2001). Importantly, the 'bilingual advantage' seems to be limited to executive function tasks that involve conflict. Research has shown that executive function tasks that are not embedded in a misleading context are solved equally well by bilinguals and monolinguals (Engel de Abreu 2011, Martin-Rhee and Bialystok 2008).

Published studies on bilingual children with SLI are extremely rare and, so far, focused almost exclusively on morphosyntactic development (see Paradis 2010, for a review). To our knowledge, only one study has explored executive functioning in bilingual children with low language proficiency (Iluz-Cohen and Armon-Lotem 2013). This study included 10 sequential bilingual English–Hebrew speaking children that were designated as 'low language proficiency' group (not SLI) by the authors. However, they did score below norms on language tests in both their languages, had performance IQ in the normal range and conformed to the conventional exclusionary criteria for SLI. Children completed two executive function tasks that were hypothesized to tap inhibition, sorting and shifting. Compared with bilingual children with high language proficiency, the low language proficiency group had significantly lower scores on inhibition and shifting but not on sorting.

### *The present study*

This is the first study to explore a broad range of executive functions in a relatively homogeneous

group of language-minority children with SLI from socioeconomically disadvantaged backgrounds. Previous research has often not included children from low-income homes. The subjects were Portuguese immigrant children living in Luxembourg with an SLI diagnosis (BiSLI), typically developing Portuguese immigrant children living in Luxembourg (BiTD) and typically developing monolingual children living in Portugal (MoTD).

Luxembourg is a small country in Western Europe with a high percentage of foreign inhabitants (43% of 512 353). The Portuguese community is by far the largest foreign-born population segment representing 16% of the total population. Preschool is compulsory in Luxembourg and all preschool children are screened for language and hearing impairments by specialized speech and language professionals every year. Children who are picked up by the screening and for whom language difficulties remain in spite of targeted classroom-based intervention are offered a free assessment by a team of psychologists, speech and language therapists, audiologists, pedagogues and physicians. Over recent years, considerable efforts have been made to unify the diagnostic procedure for identifying children with SLI across the country. A deficit in nonword repetition is regarded by many as a major clinical marker of SLI (Bishop *et al.* 2006) although some have argued that nonword repetition deficits might relate more specifically to literacy than language disorder itself (Catts *et al.* 2005). Furthermore, language impairment in the face of otherwise typical development and non-verbal abilities in the normal range is considered a major indication of SLI. If an SLI diagnosis is made by the team of professionals the child is offered either special support at school or granted an admission slot in the country's single specialized school for children with SLI. This state-run school is frequented by children from across the country, independent of their social background (no school fees are charged and transport is free and provided by the state). Portuguese–Luxembourgish bilingual children with SLI were recruited from this specialized school (see the Methods for the exact selection criteria) and their performance was compared with typically developing Portuguese–Luxembourgish speaking children from public schools in Luxembourg and monolingual Portuguese-speaking children from Portugal. Children completed a range of measures tapping verbal and visuospatial working memory (simple and complex span), selective attention, interference suppression, syntax and vocabulary (expressive and receptive).

The aim of the study was to explore whether executive functioning represents an area of difficulty for language-minority children with SLI and if so, which specific executive processes might be affected. The working memory measures that we employed all

relied on verbal or visuospatial encoding and analytical processes without a misleading context. On the basis of previous evidence (Engel de Abreu 2011, Martin-Rhee and Bialystok 2008), we predicted that these tasks would be solved equally well by typically developing bilinguals and monolinguals (i.e. BiTD = MoTD). According to the domain-general working memory deficit account (Henry *et al.* 2012), the bilingual SLI group should perform less well than the controls on measures of both verbal and visuospatial working memory (i.e. BiSLI < BiTD = MoTD). If SLI might instead be better understood as a domain-specific verbal working memory impairment (Archibald and Gathercole 2006a, Gathercole and Baddeley 1990), children with SLI should manifest reduced performance on the verbal (i.e. BiSLI < BiTD = MoTD) but not on the visuospatial working memory tasks (i.e. BiSLI = BiTD = MoTD).

Children also completed tasks that demand different levels of cognitive control. We used the flanker paradigm that has been studied extensively as a measure of interference suppression involving stimulus response incompatibility. We also administered a visual search task that requires selective attention and inhibition to be resolved successfully. Both tasks meet the criteria for the type of paradigm in which bilingual children have been found to outperform their monolingual counterparts (i.e. conflicting information, Bialystok 2001); we therefore expected that the typically developing bilinguals would outperform the monolinguals on these measures (i.e. MoTD < BiTD). Given the scarce research on bilingual children with SLI it would be premature to formulate clear predictions regarding the performance of the clinical group on these measures. One possibility is that the bilingual SLI group will perform less well than both control groups (i.e. BiSLI < MoTD < BiTD). This would provide clear evidence for a domain-general executive function deficit in SLI. A second possibility is that the results of the bilingual SLI group will resemble those found for bilingual typically developing children with both groups outperforming typically developing monolinguals (i.e. MoTD < BiSLI = BiTD). This would indicate that cognitive control might not be deficient in SLI and that the bilingual advantage, reported in typically developing bilingual children, extends to bilingual children with SLI. It is also possible that the bilingual SLI group will perform less well than typically developing children who are bilingual but better than typically developing monolinguals (i.e. MoTD < BiSLI < BiTD). Such a finding would be less straightforward to interpret. One might speculate that the cognitive advantage emerging from bilingualism overrides possible differences in cognitive control between the bilingual children with SLI and their typically developing monolingual peers that do, however, remain apparent if the

clinical group is compared with typically developing bilinguals.

## Methods

### *Participants*

The data from 81 children from three different groups was analysed: (1) 15 Portuguese–Luxembourgish bilinguals from Luxembourg with an SLI diagnosis (i.e. BiSLI); (2) 33 typically developing Portuguese–Luxembourgish bilinguals from Luxembourg (i.e. BiTD); and (3) 33 typically developing Portuguese-speaking monolinguals from Portugal (i.e. MoTD). All the children were recruited on the basis of a language and social background questionnaire that was completed by the main caregiver and that provided information on the socio-demographic characteristics of the family, the child's developmental history, the language uses in the home, the child's exposure to his/her native and foreign languages, as well as the parents' native and foreign language knowledge.

Only children who had acquired Portuguese as a first language from birth and with native Portuguese-speaking caregivers were included in the study. Parents of all participating children were first generation immigrants to Luxembourg; they all indicated not speaking the Luxembourgish language and having none or very limited understanding of Luxembourgish. Children in both bilingual groups were sequential bilinguals: Portuguese was the sole language spoken at home and Luxembourgish was formally acquired by all children in the context of the preschool education that is compulsory in Luxembourg from the age of 4. A total of 60% of the children in the BiSLI group and 70% of the children in the BiTD group had been born in Luxembourg. The remaining children had been born in Portugal and emigrated to Luxembourg before the age of 3. All children had frequented monolingual Luxembourgish preschools. The monolingual group had monolingual parents, spoke only Portuguese at home and attended monolingual schools in Portugal. All participating schools were publicly funded and had similar demographic profiles (e.g. they were not located in disadvantaged neighbourhoods, did not struggle with educational resources and all teachers were trained at bachelor or master's level).

Participants were group matched for first language, ethnicity (100% Caucasian), chronological age, and socioeconomic status. Mean ages for the three groups were as follows: BiSLI, 8 years; 0 months (SD = 7.38, range = 7;1–9;0); BiTD, 8 years; 2 months (SD = 2.63, range = 7;9–8;7); MoTD, 8 years; 1 month (SD = 3.26, range = 7;6–8;5). Socioeconomic

status was indexed by the International Socio-Economic Index of Occupational Status (ISEI) (Ganzeboom 2010) an internationally comparable index that ranges from 16 (e.g. farmhands) to 90 (e.g. judge). The index was derived from caregiver responses on caregiver occupation and was based on the highest occupational level of either caregiver. Mean ISEI indices of the groups were low [BiSLI: mean = 32, SD = 4.77; BiTD: mean = 35, SD = 6.15; MoTD: mean = 36, SD = 8.88], with the majority of parents having manual professions such as cleaners, craft workers or machine operators. All of the children achieved a standard score above 85 on the Raven's Coloured Progressive Matrices (Raven *et al.* 1986) measuring nonverbal intelligence; group differences were non-significant [BiSLI: mean = 105.81, SD = 9.80; BiTD: mean = 106.51, SD = 9.71; MoTD: mean = 108.44, SD = 12.03;  $F(2; 80) = 0.42$ ,  $p = 0.66$ ,  $\eta_p^2 = 0.01$ ]. None of the children were diagnosed with hearing problems, epilepsy, autism spectrum disorder or attention deficit/hyperactivity disorder (ADHD). Informed written consent procedures were followed for all participants.

#### *BiSLI group.*

The children were recruited from the SLI section of a special school for language and hearing impaired children in Luxembourg. Participants for whom a problem in terms of attention control was reported by caregivers or teachers were not included in the study. The sample comprised 13 boys and two girls. All children had received a formal SLI diagnosis from specialized health professionals following the clinical criteria from the International Classification of Diseases (ICD 10). Test results from the children's clinical records were made available for the purpose of this study. All of the children had normal hearing sensitivity. General cognitive ability had been assessed with the Kaufman Assessment Battery for Children (Kaufman and Kaufman 2002); all children manifested nonverbal ability scores that were in the normal range and that were at least 2 SD higher than scores on the achievement scale that mainly comprises linguistic processing. On average, children scored 1.5 SD below the mean on the Mottier test of non-word repetition (Linder and Grisseman 2000). All children performed below the 10th percentile on the language comprehension and the vocabulary subtests of the Wiener Entwicklungstest (Kastner-Koller and Deimann 1998).

We confirmed the SLI diagnosis by administering a range of standardized measures in Portuguese. Two subtests from the Avaliação da Linguagem Oral (oral language assessment test; Sim-Sim 2003) were administered: compreensão de estruturas complexas [comprehension of complex structures] and reflexão morfo-

sintáctica [test of morphosyntax]. All the children scored below the 10th percentile on these measures. The Brazilian Children's Test of Pseudoword Repetition (Santos *et al.* 2006) that was recorded by a native European Portuguese speaker was also administered and children scored on average 6.2 SD below the mean (range -10.1 to -2.25 SD).

#### *Control groups*

The typically developing children were recruited from six schools across Luxembourg (BiTD) and six schools from Northern Portugal (MoTD). In total, 121 children were assessed. The final matched sample consisted of 15 boys and 18 girls for the BiTD group and 16 boys and 17 girls for the MoTD group. Children had no history of speech, language or hearing problems, nor special educational needs according to parental reports and school records. Data from a larger sample of immigrant children (and their monolingual controls) was analysed to reduce the likelihood of unrepresentative samples.

#### *Procedure and material*

Each child was tested individually, in a calm area of the school in three sessions of approximately 30 min on successive school days. All the cognitive processing tasks were administered in Portuguese. The bilingual children completed all the language assessments (expressive and receptive vocabulary and grammar comprehension) in both their languages (Portuguese and Luxembourgish). The working memory measures were subtests from the European Portuguese version of the computerized Automated Working Memory Assessment (AWMA) (Alloway 2007). The measures were administered in a fixed sequence designed to vary the nature of the task demands across successive tests. Children received a sticker after completing different phases of the assessment and a diploma for their participation at the end of testing. Reliability coefficients of the measures are reported in the results section. For all the analyses, raw scores were used as dependent variables as no standardized norms in a population of children from Luxembourg or Portugal are available.

#### *Verbal working memory*

Two tasks of verbal working memory were administered: the *digit recall* and the *counting recall* task (Alloway 2007). In the *digit recall* task children are presented with sequences of spoken digits that they have to repeat immediately in the same order as they were presented. In the *counting recall* task children have to count and memorize the number of circles in arrays containing triangles and circles. At the end of each trial the number of circles



in each array has to be recalled in the correct order. The number of correctly recalled trials serves as the dependent variables for both measures.

#### *Visuospatial working memory*

Children completed the *dot matrix* and the *odd-one-out* tasks as measures of visuospatial working memory (Alloway 2007). In the *dot matrix* task, a red dot appears in different locations of a  $4 \times 4$  matrix and children have to recall the sequence of locations by tapping the squares of the empty matrix in the right order at the end of each trial. The *odd-one-out* task consists of arrays of three boxes with one abstract shape in each and children are required to identify the odd shape that does not match with the others. At the end of the trial they are presented with an array of three empty boxes and are asked to recall the localization of the odd shape of each array by tapping the empty boxes in the right order. The number of correctly recalled trials serves as the dependent variables for both measures.

#### *Selective attention*

Children completed the *sky search* task from the Test of Everyday Attention for Children (Manly *et al.* 1998). In this test, children are presented with an A3 sheet containing paired spacecrafts of which 20 are identical pairs and 108 are lures. They have to identify the identical pairs as fast as possible. The dependent variable used for analyses is the time-per-target score adjusted for motor speed.

#### *Interference suppression*

Interference suppression was assessed with a *flanker task*, that was modified from Rueda *et al.* (2004) and that is described in detail in Engel de Abreu *et al.* (2012). The task is computerized and administered with response buttons. Children have to indicate the direction of a central fish in a row of five fish by pressing the corresponding left or right response button as fast as possible. On congruent trials (50%), the flanking fish are pointing in the same direction as the target, and on incongruent trials, the distracter fish point in the opposite direction. Response time (RTs) and accuracy are recorded. All children scored above 80% correct on the task. The dependent variable used for analyses was RT on incongruent trials. Incorrect responses, RTs below 200 ms, and RTs above 3 SD of children's individual means were excluded from the analyses.

#### *Language*

Children completed the Expressive One Word Picture Vocabulary Test (Brownell 2000) in which they have

to name pictures. A predetermined fixed set of 51 items was administered to all children. Receptive vocabulary was assessed with the Peabody Picture Vocabulary Test—4 (Dunn and Dunn 2007). Children are required to match a spoken word to a picture out of a choice of four. The same 64 items were administered to all children. Portuguese items were selected from form A and Luxembourgish equivalents from the parallel form B of the test. The Test for Reception of Grammar—2 (Bishop 2003) was administered to assess grammatical understanding. Children have to identify a target picture out of four that corresponds to a spoken sentence. A predetermined fixed set of 20 items was administered with parallel sentences for each language version.

### **Results**

Descriptive statistics are provided in table 1. Skewness and Kurtosis for all the variables met criteria for univariate normality. Reliability coefficients of all the measures were in an acceptable range. Data were analysed using one-way between-subjects analysis of variance (ANOVA) followed by Tamhane's T2 post-hoc test adjusting for unequal sample size (table 2). The  $p$ -value was set at 0.05 to decide the significance in group differences. All ANOVAs were accompanied by a partial Eta-squared ( $\eta_p^2$ ) value as a measure of effect size. Where significant differences were found in post-hoc tests, Cohen's  $d$  was calculated as an effect size measure when comparing two groups (table 2). Thresholds of 0.20, 0.50 and 0.80 were used for small, moderate and large effect sizes, respectively (Cohen 1992).

Results on the language measures indicate significant and large group effects on all the tasks. The BiSLI group manifested reduced performance compared with the BiTD group on the Luxembourgish vocabulary measures [expressive,  $F(1, 46) = 6.70$ ,  $p = 0.01$ ,  $\eta_p^2 = 0.13$ ; receptive,  $F(1, 46) = 13.97$ ,  $p = 0.00$ ,  $\eta_p^2 = 0.23$ ]. No significant differences between both groups emerged on the Portuguese expressive and receptive vocabulary tasks; there was, however, a clear tendency of reduced performance of the BiSLI group especially on Portuguese expressive vocabulary ( $p = 0.05$ ; Cohen's  $d = 0.85$ ). On the measures of grammatical understanding the BiSLI group performed significantly less well than the BiTD group in Luxembourgish (Cohen's  $d = 1.71$ ) and in Portuguese (Cohen's  $d = 0.97$ ). The MoTD outperformed both bilingual groups on all the Portuguese language measures (Cohen's  $d$  ranging from 1.44 to 3.83).

The three groups performed equally well on the visuospatial working memory tasks. Group differences emerged, however, on the verbal working memory measures. On digit recall, the BiSLI group performed significantly less well than both typically developing groups

Table 1. Reliability, descriptive statistics, and significance tests for language and executive function measures according to group

	$\alpha$	BiSLI (n = 15)		BiTD (n = 33)		MoTD (n = 33)		Significance		
		Mean (SD)	CI	Mean (SD)	CI	Mean (SD)	CI	F	p	Effect size
<i>Language measures</i>										
<i>Portuguese</i>										
Expressive vocabulary <sup>a</sup>	0.84	18.07 (6.56)	14.43, 21.70	22.88 (5.25)	21.02, 24.74	36.21 (3.66)	34.92, 37.51	<b>92.68</b>	<b>0.00</b>	<b>0.70</b>
Receptive vocabulary <sup>b</sup>	0.77	38.87 (9.77)	33.46, 44.28	42.52 (6.02)	40.38, 44.65	54.73 (3.32)	53.55, 55.90	<b>49.61</b>	<b>0.00</b>	<b>0.56</b>
Grammar <sup>c</sup>	0.56	12.87 (1.81)	11.87, 13.87	14.94 (2.25)	14.14, 15.74	17.73 (1.57)	17.17, 18.28	<b>37.50</b>	<b>0.00</b>	<b>0.49</b>
<i>Luxembourgish</i>										
Expressive vocabulary <sup>a</sup>	0.83	12.80 (3.00)	11.14, 14.46	16.88 (5.73)	14.85, 18.91	–	–	<b>6.70</b>	<b>0.01</b>	<b>0.13</b>
Receptive vocabulary <sup>b</sup>	0.68	34.07 (4.79)	31.41, 36.72	40.45 (5.77)	38.41, 42.50	–	–	<b>13.97</b>	<b>0.00</b>	<b>0.23</b>
Grammar <sup>c</sup>	0.74	12.20 (2.11)	11.03, 13.37	15.39 (1.75)	14.77, 16.01	–	–	<b>30.19</b>	<b>0.00</b>	<b>0.40</b>
<i>Executive function measures</i>										
<i>Verbal working memory</i>										
Digit recall	0.92	18.27 (3.26)	16.46, 20.07	22.06 (4.49)	20.47, 23.65	24.33 (4.39)	22.78, 25.89	<b>10.57</b>	<b>0.00</b>	<b>0.21</b>
Counting recall	0.91	13.60 (5.22)	10.71, 16.49	15.97 (3.48)	14.74, 17.20	17.45 (3.93)	16.06, 18.85	<b>4.78</b>	<b>0.01</b>	<b>0.11</b>
<i>Visuospatial working memory</i>										
Dot matrix	0.93	20.13 (4.05)	17.89, 22.38	19.33 (4.31)	17.80, 20.86	20.24 (3.85)	18.88, 21.61	0.45	0.64	0.01
Odd one out	0.91	16.53 (3.54)	14.57, 18.50	15.15 (4.00)	13.73, 16.57	15.39 (4.02)	13.97, 16.82	0.66	0.52	0.02
<i>Selective attention</i>										
Sky search (s)	na	5.62 (1.98)	4.52, 6.72	5.21 (1.48)	4.71, 5.72	6.31 (2.01)	5.60, 7.02	<b>3.15</b>	<b>0.04</b>	<b>0.08</b>
<i>Interference suppression</i>										
Flanker (ms)	0.84	924.43 (209.48)	808, 1040	770.80 (124.43)	727, 815	945.91 (285.63)	845, 1047	<b>5.86</b>	<b>0.00</b>	<b>0.13</b>

Note:  $p < 0.05$  is marked in boldface. Effect size is based on  $\eta_p^2$ : small effect (about 0.01), moderate effect (about 0.06) and large effect (about 0.14). CI: 95% confidence interval. BiSLI: Portuguese–Luxembourgish bilingual children from Luxembourg with SLI. BiTD: typically developing Portuguese–Luxembourgish bilingual children from Luxembourg. MoTD: typically developing monolingual Portuguese-speaking children from Portugal.

<sup>a</sup>Expressive One Word Picture Vocabulary Test (Brownell 2000).

<sup>b</sup>Peabody Picture Vocabulary Test–4 (Dunn and Dunn 2007).

<sup>c</sup>Test for Reception of Grammar—2 (Bishop 2003).

Table 2. Post-hoc analysis of group differences in language and executive function scores

	BiSL-BiT			BiSL-MoTD			BiTD-MoTD		
	Mean difference	<i>p</i>	Effect size	Mean difference	<i>p</i>	Effect size	Mean difference	<i>p</i>	Effect size
<i>Language measures</i>									
<i>Portuguese</i>									
Expressive vocabulary <sup>a</sup>	-4.81	0.05	-0.85	-18.14	<b>0.00</b>	<b>-3.83</b>	-13.33	<b>0.00</b>	<b>-2.95</b>
Receptive vocabulary <sup>b</sup>	-3.65	0.48	-0.50	-15.86	<b>0.00</b>	<b>-2.62</b>	-12.21	<b>0.00</b>	<b>-2.51</b>
Grammar <sup>c</sup>	-2.07	<b>0.01</b>	<b>-0.97</b>	-4.86	<b>0.00</b>	<b>-2.95</b>	-2.79	<b>0.00</b>	<b>-1.44</b>
<i>Luxembourgish</i>									
Expressive vocabulary <sup>a</sup>	-4.08	<b>0.01</b>	<b>-0.81</b>	-	-	-	-	-	-
Receptive vocabulary <sup>b</sup>	-6.38	<b>0.00</b>	<b>-1.16</b>	-	-	-	-	-	-
Grammar <sup>c</sup>	-3.19	<b>0.00</b>	<b>-1.71</b>	-	-	-	-	-	-
<i>Executive functions</i>									
<i>Verbal working memory</i>									
Digit recall	-3.79	<b>0.01</b>	<b>0.91</b>	<b>-6.07</b>	<b>0.00</b>	<b>1.49</b>	-2.27	0.12	0.51
Counting recall	-2.37	0.33	0.58	-3.85	0.05	0.88	-1.48	0.29	0.40
<i>Visuospatial working memory</i>									
Dot matrix	no significant difference			no significant difference			no significant difference		
Odd one out	no significant difference			no significant difference			no significant difference		
<i>Selective attention</i>									
Sky search (s)	0.40	0.87	0.25	-0.69	0.62	0.34	-1.10	<b>0.04</b>	<b>0.62</b>
<i>Interference suppression</i>									
Flanker (ms)	153.63	<b>0.04</b>	<b>0.99</b>	-21.48	0.99	0.08	-175.11	<b>0.01</b>	<b>0.79</b>

Note:  $p < 0.05$  is marked in boldface. Effect size is based on  $\eta_p^2$ : small effect (about 0.01), moderate effect (about 0.06) and large effect (about 0.14). CI: 95% confidence interval. BiSL: Portuguese–Luxembourgish bilingual children from Luxembourg with SLI. BiTD: typically developing Portuguese–Luxembourgish bilingual children from Luxembourg. MoTD: typically developing monolingual Portuguese-speaking children from Portugal.

<sup>a</sup>Expressive One Word Picture Vocabulary Test (Brownell 2000).

<sup>b</sup>Peabody Picture Vocabulary Test—4 (Dunn and Dunn 2007).

<sup>c</sup>Test for Reception of Grammar—2 (Bishop 2003).



[ $F(2, 78) = 10.57, p = 0.00, n_p^2 = 0.21$ ] that did not differ significantly from each other (BiSLI < BiTD = MoTD). The BiSLI group also manifested the lowest performance on counting recall (Cohen's  $d$  of 0.58 and 0.88). Although the overall group effect was significant [ $F(2, 78) = 4.78, p = 0.01, n_p^2 = 0.11$ ], post-hoc analyses just failed to reach the level required for statistical significance.

Results on the sky search and the flanker tasks indicate significant group differences [sky search:  $F(2, 78) = 3.15, p = 0.04, n_p^2 = 0.08$ ; flanker:  $F(2, 78) = 5.86, p = 0.00, n_p^2 = 0.13$ ]. On both measures the BiTD group was significantly faster than the MoTD group (Cohen's  $d$  of 0.62 and 0.79) and performance of the BiSLI group fell between the performance of the BiTD and MoTD groups. On the sky search task, results of the BiSLI group did, however, not differ significantly from either control group. On the flanker task, performance of the BiSLI and the MoTD groups was equivalent and both groups were significantly slower than the BiTD group (BiSLI = MoTD < BiTD; BiSLI–BiTD, Cohen's  $d$  of 0.99).

Because the BiSLI group contained an excess of boys, the effect of sex on task performance was examined in the typically developing groups. Results showed that there was no significant difference between boys and girls for any of the measures.

## Discussion

The number of research studies involving bilinguals has increased substantially in recent years. Yet few have studied bilingual children with SLI and even fewer have been conducted outside the English-speaking world. Such studies are challenging because bilinguals with SLI constitute a heterogeneous population and many countries lack standardized tests and procedures to make a formal SLI diagnosis in the context of second language acquisition.

This unique study explored executive functioning and language abilities in bilingual children with SLI from low-income Portuguese immigrant families living in Luxembourg. The bilingual SLI group was carefully matched on first language (Portuguese), age and socioeconomic background to two groups of typically developing children: one bilingual group from Luxembourg from the same immigrant population as the children with SLI and one monolingual group from Portugal—the country of origin of the bilinguals from Luxembourg.

The study showed that the lexical development of the bilingual SLI group in the first language Portuguese was comparable to the bilingual language-minority group that had not received a formal diagnosis of SLI.

This result provides further evidence to support the claim that typically developing language-minority children can produce linguistic patterns that superficially resemble those of children with SLI (Armon-Lotem 2012, Engel de Abreu *et al.* 2013, Thordardottir *et al.* 2006). The Portuguese language measure that distinguished the clinical group from their typically developing peers was the Test for Reception of Grammar (Bishop 2003), a measure of syntactic understanding. This result fits well with the position that difficulties with grammar represent a major hallmark of SLI (Bishop *et al.* 2000). It also shows that the bilingual SLI group under investigation here demonstrated similar characteristics to monolingual English-speaking children with SLI, the population most involved in previous research.

As expected, the typically developing bilinguals did not outperform the monolinguals on measures of working memory. This is most likely because the measures that we used did not involve conflicting information (Engel de Abreu 2011, Martin-Rhee and Bialystok 2008). The study provides no evidence to suggest that the working memory deficits of children with SLI are domain-general. The bilingual SLI group demonstrated limitations in verbal working memory but performed equally well to both typically developing groups on visuospatial working memory tasks. Group differences were most pronounced for the digit recall task. Although children with SLI also performed less well than their typically developing peers on the counting recall task (with effect sizes of 0.58 and 0.88), group differences just failed to reach the criterion for statistical significances.

The findings are in line with the positions that verbal working memory deficit might represent a contributing factor to the language learning difficulties in individuals with SLI (Archibald and Gathercole 2006a, Gathercole and Baddeley 1990). The data conflicts with a recent study by Henry *et al.* (2012) in which monolingual children with SLI were found to also have limitations in visuospatial working memory (see also Im-Bolter *et al.* 2006, Marton 2008). As no bilingual advantage on visuospatial measures of working memory was observed in the typically developing groups it seems unlikely that the bilingual children with SLI were protected from domain-general working memory difficulties by their bilingualism. Instead a possible reason for discrepancies with previous research is that visuospatial working memory difficulties might not be specific to SLI but represent a correlate of co-morbid impairments. Clinically meaningful levels of inattention are often reported in children with SLI and increasing evidence suggests that visuospatial working memory deficits represent a core component of ADHD (Martinussen and Tannock 2006, Williams *et al.* 2000). Marton's (2008) study indicates that whether children with SLI are found

to be impaired relative to controls on visuospatial working memory tasks depends on their attention skills. Henry *et al.* (2012) acknowledged that although their study excluded children with ADHD, subclinical levels of attention deficit were not controlled. The present study adopted more stringent selection criteria and excluded children with an ADHD diagnosis as well as children with attention problems as defined by parents' and teachers' reports. It would be of interest if future studies would include ratings of attention to gain a fuller appreciation of the specific cognitive underpinnings of SLI. One possibility is that SLI is a disorder of multiple underlying deficits (Bishop 2006) and that visuospatial working memory deficits constitute one of many risk factors that can compromise language learning.

The typically developing bilinguals showed an advantage over their monolingual peers on measures of selective attention and interference suppression consistent with the position that a bilingual experience fosters the development of specific cognitive processes that are involved in dealing with conflicting information (Bialystok 2001). Effect sizes were larger for interference suppression than for selective attention, indicating that both types of tasks do not demand the same level of cognitive control. Bilingual children with SLI did not differ significantly from both typically developing groups on the measure of selective attention. For interference suppression, however, a significant difference between the bilingual SLI group and the bilingual typically developing group emerged. This result is consistent with a previous study on bilingual children with low language proficiency who demonstrated deficits on an embedded figure task involving misleading contexts (Iluz-Cohen and Armon-Lotem 2013). Importantly, a significant difference on interference suppression did not emerge when the bilingual SLI group was compared with the monolingual typically developing group. This pattern of findings could indicate that the cognitive advantage emerging from bilingualism overrides possible differences in interference suppression between the bilingual SLI and the monolingual typically developing groups that does, however, remain apparent if the clinical group is compared with typically developing bilinguals. Further studies involving monolingual children with SLI are clearly needed in order to test this hypothesis.

There are two noteworthy limitations of this study: small sample size and the lack of a monolingual SLI control group. The BiSLI group only contained 15 children and statistical power may not have been sufficiently high to provide sensitivity to small yet consistent differences. With larger sample sizes, group differences on some of the measures (for example counting recall) are likely to have emerged. The study did not include a monolingual SLI control group which would have allowed to deter-

mine more clearly whether bilingualism might represent a protective factor against potential domain-general executive function limitations in SLI.

## Conclusions and implications

Increased migration has led to a rising number of children from immigrant backgrounds speaking several languages (Organisation for Economic Co-operation and Development (OECD) 2010, US Census Bureau 2004). Building and increasing the research base on children with SLI who are exposed to more than one language are therefore of critical importance for both basic science and clinical practice. This research provides further support to the position that SLI is not language specific and extends it to young bilingual children. The study indicates that although bilingual children with SLI do not demonstrate the same advantages in selective attention and interference suppression as typically developing bilinguals, they do not lag behind typically developing monolinguals in these domains of executive functioning. This finding raises the possibility that bilingualism might play a role in the expression of domain-general processing deficits in SLI.

The study has potential implications for clinical and educational practice. Results indicate that relative to monolinguals, typically developing language-minority children are disadvantaged on traditional language assessments but not on working memory tasks. Importantly, assessments of verbal working memory differentiated children with SLI from the typically developing groups and have been shown in other studies to be relatively unaffected by test language and cultural status (Engel de Abreu *et al.* 2008, 2013). Measures of verbal working memory might therefore represent a promising tool to determine whether low scores on language assessments are attributable to a child's sociolinguistic background or to the presence of a neurolinguistic disorder. This might contribute towards research-based effective practices and improvement of the education of disadvantaged students.

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